THE WINDS OF THE MIDDLE AND NORTHERN CALIFORNIA COAST

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In some recent studies of the pressure distribution and the resulting winds of the California coast a few details came to light which seem worthy of preservation in the literature of the climatology of the United States.

Reference is made to the high winds and gales that are experienced in the months April to July, inclusive, along the middle and northern stretch of the California coast.

The studies in question showed that in general the winds of the California coast from the Golden Gate to and perhaps beyond Cape Mendocino have a pronounced seasonal increase in strength, the first in midwinter when land winds sweep down the Coast Range of mountains and out upon the Pacific with velocities which at times approach and indeed exceed 100 miles per hour; the second seasonal increase is in late spring and early summer months when the direction of the wind is exactly the opposite of that which prevails in midwinter, viz, from the ocean to the land.

The strength of these winds in winter depends upon the pressure gradient which obtains for the time being. A deep barometric depression over the ocean approaching the California coast when the Great Basin region is occupied by an anticyclone in which pressures are 30.40 inches and upwards is the occasion for high southeast winds and gales along the coast. Conversely the presence of an extensive trough of low pressure over California with its axis trending north-south in conjunction with an anticyclone over the Pacific, even though the central pressure in it does not exceed 30.10–30.15 inches, provided the surface temperatures in interior California are relatively high, is the occasion for northwest winds and gales over the ocean near the coast and also over the coast range directly to the eastward.

The prevailing winds.—The prevailing wind direction at stations along the California coast, as deduced from twice-daily eye observations, together with the length of the record at each station is set forth in the subjoined table. This table contains also the data for three stations in the interior.

TABLE 1.—*Prevailing winds*

Stations	Length of record years	January	February	March	April	May	June	July	August	September	October	November	December
Roseburg, Oreg.	45	s.	s.	s.	nw.	nw.	nw.	n.	n.-nw.	n.-nw.	nw.	s.	s.
Eureka, Calif.	35	se.	se.	se.	n.	n.	nw.	nw.	nw.	n.	n. se.	se.	se.
Point Reyes, Calif.	35	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.
Southeast Farallon, Calif.	10	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.
Mount Tamalpais, Calif.	21	se.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw	nw.
San Francisco, Calif.	52	n.	w.	w.	w.	w.	w.	w.	sw.	w.	w.	w.	n.
San Diego, Calif.	50	nw.	nw.	nw.	nw.	w.	sw nw	nw	nw.	nw.	nw.	nw.	ne.
Valley stations:													
Red Bluff	45	nw.	nw.	nw.	se.	se.	se.	se.	se.	nw.	nw.	nw.	nw.
Sacramento	46	se.	se.	se.	s.	s.	s.	s.	s.	s.	se.	se.	se.
Fresno	35	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.	nw.

The prevailing winds at both Roseburg, Oreg., and Eureka, Calif., are from a southerly or land quarter from November to April, a fact due, in the opinion of the writer, to the very intimate control exercised by the Great Basin anticyclone of the cold months. At the remaining stations along the coast, while the prevailing direction is northerly in the cold months, yet southerly winds prevail for much of the time; in fact, at Point Reyes there are almost as many January and December months with prevailing winds from a southerly quarter as from a northerly quarter. The prevailing winds at San Francisco are largely the result of topographic control. Although the record for Southeast Farallon—a rocky island 28 miles from the entrance to Golden Gate—shows northwest to be the prevailing direction for each month of the year, southerly winds are almost as prevalent in January as northwest.

The coastal winds of the Golden Gate region.—The records used are those of Point Reyes, on the coast, Mount Tamalpais, altitude 2,375 feet, a few miles inland, San Francisco, and Southeast Farallon. The positions of these four stations are shown in the small sketch map, Figure 1.

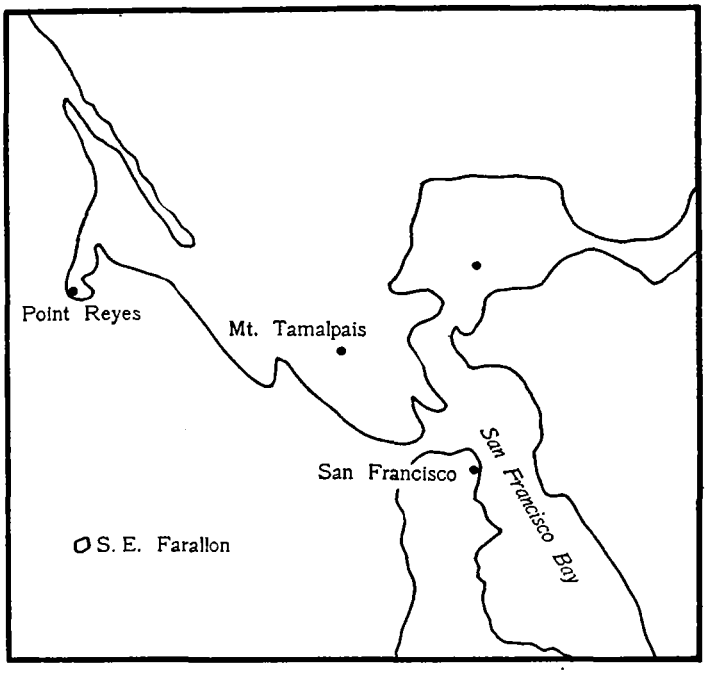

FIG. 1

The monthly mean wind speed at the four stations above named, together with the maximum speed for each month and the direction at time of maximum, is given in Table 2.

TABLE 2.—*Mean monthly wind velocity (mi. p. h.)*

Stations	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Point Reyes	17.7	19.5	20.8	23.8	26.1	26.9	22.1	19.8	18.2	17.0	16.6	16.5	20.4
Mt. Tamalpais	19.9	18.3	18.1	18.9	19.5	18.5	15.0	14.2	15.2	16.0	17.6	19.7	17.6
SE. Farallon	15.7	15.3	17.0	17.1	19.1	18.5	15.6	13.9	12.6	12.8	12.9	13.2	15.3
San Francisco	7.4	7.5	8.8	10.1	11.2	12.6	13.1	12.1	10.1	7.8	6.7	6.8	9.5
	Maximum velocities and direction												
Point Reyes	104 nw.	101 nw.	108 sw.	110 nw.	120 nw.	94 nw.	90 nw.	76 nw.	75 nw.	90 nw.	82 se.	96 s.	----
Mt. Tamalpais	90 se.	76 nw.	88 nw.	92 nw.	92 nw.	92 nw.	89 nw.	78 nw.	80 nw.	78 nw.	88 n.	78 sw.	----
SE. Farallon	66 nw.	68 n.	72 se.	60 n.	60 nw.	54 nw.	55 nw.	50 n.	58 nw.	58 nw.	61 nw.	76 s.	----
San Francisco	57 se.	52 s.	60 s.	47 nw.	45 w.	48 sw.	41 w.	42 sw.	42 sw.	44 ne.	64 ne.	60 se.	----
Cape Mendocino.[2]	124 se.	104 se.	92 se.	100 se.	[1] 130	64 se.	56 s.	52 se.	96 se.	82 se.	125 se.	108 se.	----

[1] Estimated. [2] 5 years' record.

It is obvious that the values contained in the above table can not be rigorously correct. If we assume that the record for Southeast Farallon is approximately correct for the water surface, then the values for Point Reyes and Mount Tamalpais should be lowered to offset the increase due to topography, the former by 33 per cent and the latter by 15 per cent, annual averages considered. The San Francisco record due possibly to surface friction and topographic controls should be increased approximately 38 per cent. The figures for Southeast Farallon show a slight decrease January to February, then an increase to May, when the maximum of the year is reached. The increase, January to May, at Southeast Farallon is 3.4 miles, whereas the increase for the same months at Point Reyes is 8.4 miles, more than double that of the first named. This is considered as being due to the great temperature contrast between interior California and the ocean.

Average velocities for the month as high as 35.5 miles per hour in May have been recorded at Point Reyes and the extraordinary average of 34.5 miles per hour in July was registered at this station in 1909. Naturally when the average is high, individual days have high winds and gales rather frequently, thus maximum velocities as high as 100 miles per hour and over have been recorded at Point Reyes in each month January to May, inclusive; see lower part of Table 2.

These high velocities are sometimes continuous for 48 hours, as on May 17–18, 1902, when the average for the two days was 72 miles per hour, (1) and for the 12 hours ending midnight May 18 the average velocity was 84 miles per hour. The largest number of miles recorded on this occasion in any one hour was 102 between 8 and 9 p. m. seventy-fifth meridian time. Such high winds as these doubtless prevail along the coast from the Golden Gate northward to Cape Mendocino and perhaps beyond.

In the eighties the United States Signal Service maintained an observing station at Cape Mendocino; during the lifetime of this station a maximum velocity of 144 miles per hour was reported.

The writer has examined the original wind sheet for the day on which this extraordinary velocity was reported, viz, January 20, 1886, 7 a. m. seventy-fifth meridain time, or approximately 4 a. m. local time. At this hour artificial light was necessary. The registering apparatus was of the standard type used in those days and the record was made by a pencil lead; naturally when high winds had prevailed for some time the pencil point became dulled and the record was accordingly, more or less difficult to read. The actual velocity at 7 a. m., read under the most favorable conditions as to light, was only about one-half of the reported velocity. Nevertheless the wind speed increased rapidly and a clearly indicated velocity of 120 miles per hour was reached at 11.30 a. m. of the same date, this high velocity continued unabated to about 1.15 p. m., when the observer sharpened the registering lead pencil, thus making it possible to read the indicated velocity with greater accuracy; at this time a velocity of 123.6 was clearly registered; shortly afterwards the register ceased to function and the remainder of the record was lost.

I have added the record of maximum monthly wind velocities at Cape Mendocino to Table 2.

Cape Mendocino is the most western point of California. The terrain back of the coast line is wooded and extremely rugged, the 1,000-foot contour line approaches to within 25 miles of the shore line and is much serrated directly east of the cape by gorges, canyons, and stream valleys that lead to the Pacific. Eighty miles to the southeast of the cape the hills which in that part of California trend almost north-south rise to an altitude of 4,000 feet. The winds which we are considering therefore are down-slope winds and consequently dry. That they advance any considerable distance over the Pacific is improbable but since they prevail only at such times as a pronounced depression of the barometer is approaching the coast it would appear that they must operate to prevent the depression from gaining a foothold over the continent.

DIURNAL VARIATION OF THE WIND

The statement has been made hereinbefore that the strength of the spring and early summer winds is conditioned, in part, by the strong temperature contrast between the heated interior and the coast. In further elaboration of that idea I have computed the mean hourly wind speed for the same 10-year period at both Point Reyes and Mount Tamalpais. The means appear in Table 3 and I have plotted the June means to form the two curves in Figure 2.

TABLE 3.—*Hourly wind velocities. Meridian of time used, 120°*

Date	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.	Mid-night	Mean
	Point Reyes																								
January	20.9	20.7	20.8	20.7	20.8	20.4	20.0	20.2	19.7	19.3	19.3	19.4	19.9	20.0	20.3	20.8	21.5	21.8	22.1	21.8	22.3	21.1	21.2	21.0	20.7
February	21.4	21.0	20.7	20.6	20.3	19.7	19.8	19.6	18.5	18.0	18.1	18.4	19.6	20.5	21.3	21.7	22.3	22.6	22.7	22.9	22.8	22.7	22.4	21.8	20.8
March	23.0	22.3	22.4	21.7	21.2	20.2	19.9	19.7	19.0	18.3	18.4	18.8	20.1	21.1	21.7	22.9	23.9	24.6	25.1	25.1	25.0	24.6	24.4	23.9	22.0
April	24.3	24.1	23.9	23.5	23.4	22.6	21.9	21.2	20.6	20.3	20.7	21.2	22.4	23.4	24.4	25.8	27.3	26.9	27.4	27.5	27.1	26.2	25.7	24.9	24.0
May	26.2	26.2	25.6	25.1	24.6	23.8	23.0	22.6	21.7	21.4	21.9	22.4	23.6	24.4	25.3	26.4	27.7	28.4	28.8	29.0	28.3	28.0	27.6	27.0	25.4
June	29.5	29.2	28.6	28.1	27.1	26.3	25.4	24.6	23.9	23.6	24.1	24.6	26.0	26.8	28.2	29.7	30.8	31.9	32.3	32.6	32.6	31.5	31.0	30.0	28.2
July	23.6	23.2	22.6	22.2	21.8	21.0	20.2	19.3	18.6	18.4	18.4	18.7	19.9	20.6	21.8	23.0	24.5	25.2	25.6	26.0	25.8	25.4	24.6	24.0	22.3
August	22.7	22.4	22.1	21.8	21.6	20.8	20.0	19.5	18.5	18.1	17.9	18.1	19.3	20.1	21.1	21.9	23.6	24.5	24.6	24.9	24.6	24.2	24.0	23.1	21.6
	Mount Tamalpais																								
January	21.2	21.4	21.5	21.6	21.4	21.2	21.6	21.7	20.8	19.7	18.4	17.4	17.4	17.3	17.3	17.6	18.8	19.8	20.8	21.4	21.6	21.8	21.6	21.2	20.2
February	20.3	20.2	20.0	19.9	20.3	20.3	20.2	19.5	18.0	16.3	14.6	13.4	13.7	13.6	13.8	14.5	15.7	17.3	18.7	19.3	19.5	19.7	20.2	20.3	17.9
March	20.4	20.2	19.5	19.2	18.8	18.9	18.9	18.0	16.1	14.9	13.8	12.8	13.3	12.5	13.3	14.1	14.9	16.4	18.4	19.4	20.1	19.9	20.1	19.7	17.2
April	21.5	21.5	21.4	21.1	20.5	20.2	18.8	17.1	14.7	12.8	11.7	11.0	11.7	12.2	13.3	14.3	16.1	17.9	19.5	21.0	22.0	22.6	22.4	21.8	17.8
May	22.7	22.8	22.6	22.0	21.7	20.5	18.2	15.4	13.9	11.6	10.7	10.8	11.5	12.4	13.4	15.0	17.2	19.2	22.0	23.9	24.0	24.0	23.8	23.2	18.4
June	23.0	22.4	21.7	21.5	20.7	18.8	16.8	14.1	12.8	9.9	9.0	7.8	9.4	10.1	11.6	13.4	15.8	18.2	20.6	22.8	24.4	24.5	24.4	23.6	17.4
July	18.9	18.2	17.8	17.5	17.2	15.7	14.0	12.2	10.5	9.0	7.8	7.0	7.0	7.3	8.1	9.6	12.4	14.8	17.3	19.2	20.5	20.8	20.5	19.3	14.3
August	18.4	17.9	17.6	17.0	16.8	15.6	14.0	11.7	10.2	8.7	7.8	7.4	7.6	7.8	8.5	10.1	12.0	13.9	16.3	18.3	19.9	20.3	20.0	19.1	14.0

The chief point of interest in the above table is in the relatively large increase in the speed of the wind at Point Reyes from winter to early summer, especially at the hour of daily maximum. In January the daily maximum is 22.3 miles per hour at 9 p. m.; in June the daily maximum is 32.6 miles per hour, an increase of 10.3 over and above that of January. This increase begins in March and with the coming of summer reaches the value just quoted. At the other station, Mount Tamalpais, the speed of the wind falls off from a maximum in January to a minimum in August, as shown in the annual curves in Figure 2.

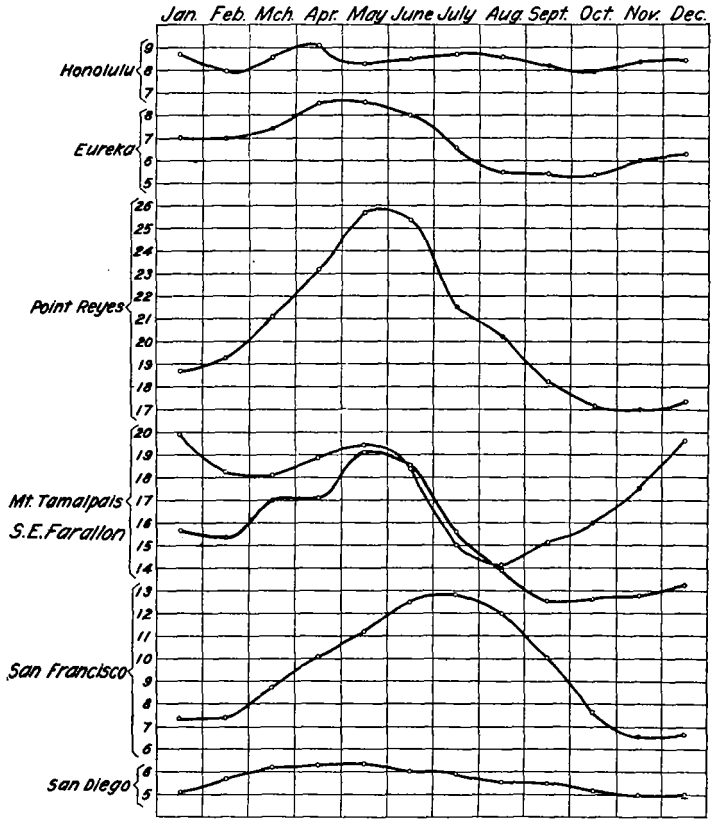

FIG. 2.—Annual march of wind velocity at certain California stations and Honolulu

The range in hourly wind speed at Point Reyes in January is 3 miles per hour; in March as the temperature of the interior rises it is 6.8 miles per hour and in June has risen to 9 miles per hour, a threefold increase over January. Mount Tamalpais, with the same range in January as Point Reyes, increases more rapidly as the warm season comes on, being 7.9 miles per hour in March and 16.7 in June. Other details appear in Table 3.

Another point of interest in the diurnal winds of the middle California coast is the delayed occurrence of the morning minimum until 10 o'clock in the forenoon. This feature comes somewhat as a surprise, although it need not, since the writer published in the annual report of the Chief of the Weather Bureau, 1896–7 pages 110–123, statistics of hourly wind velocities which show for the two stations San Francisco, Calif., and Portland, Oreg., a lag of several hours in the occurrence of the morning minimum as well as the afternoon maximum. The statistics here referred to are for seventy-fifth meridian time while those used in the present compilation are for one hundred and twentieth meridian. San Diego on the south coast of California does not show the characteristic above mentioned.

The diurnal variation at Mount Tamalpais, follows that of Point Reyes with a lag of about 2 hours in the occurrence of the morning minimum and the afternoon maximum, respectively. The daily range in velocity at Tamalpais is considerably greater than that at Point Reyes, as might be expected considering that the latter is a mountain station.

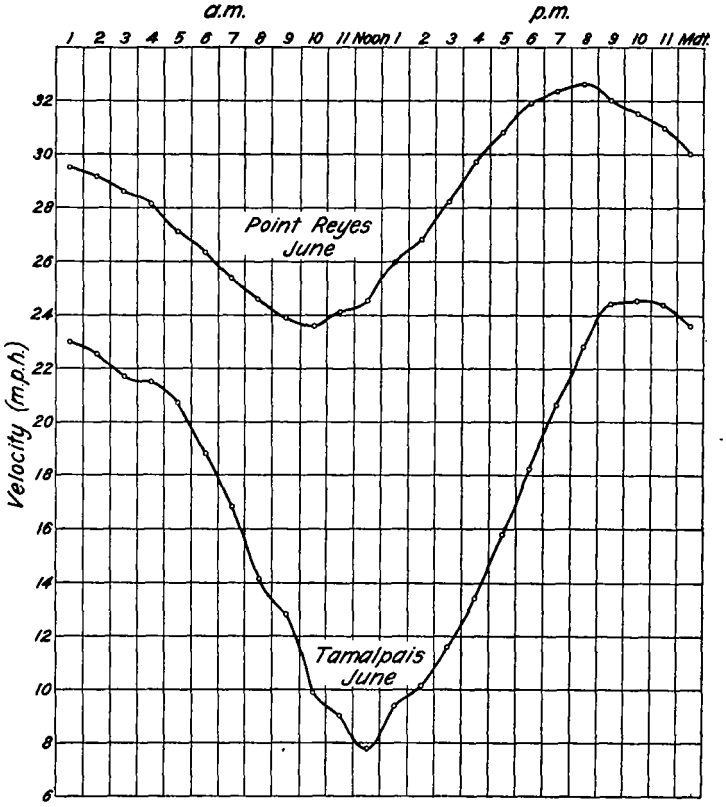

FIG. 3.—Hourly March of wind velocity in June, at Point Reyes and Mount Tamalpais

Von Hann investigated the diurnal wind movement at mountain stations many years ago. He found for the Sonnblick in the Austrian Alps, and for other mountain stations, a retardation in the time of the morning minimum and attributed it to a temperature effect on the mountain sides. In the case here considered it seems probable that the temperature effect of the Great Valley of California overshadows any temperature effect due to the slopes of Tamalpais itself, and that consequently the winds of that station join in the general northwest current that originates at sea, probably not far from the coast line, passes over the coast range of mountains and mingles with the air over the Great Valley.

LITERATURE CITED

(1) McADIE, A. G., and THOMAS, W. W.
1903. SOME HIGH WINDS ON THE PACIFIC COAST. Mo. Wea. Rev., 31: 65.